CALIFORNIA DIVISION OF MINES AND GEOLOGY

FAULT EVALUATION REPORT FER-85

January 23, 1979

1. Name of fault

San Jacinto, Hemet area (includes segments of the Casa Loma, Claremont, and Hot Springs faults).

2. Location of faults

Hemet and San Jacinto 7.5 - minute quadrangles, Riverside County (See Figure 1).

3. Reason for evaluation

Part of 10-year program and request by Riverside County geologist, Anthony B. Brown, to rezone.

4. List of references

California Department of Water Resources, 1959, Santa Ana River investigations: California Department Water Resources Bulletin No. 15, 207 p., app., and maps (scale 1:125,000).

California Division of Mines and Geology, 1974, Official Maps of Special Studies Zone, Hemet and San Jacinto quadrangles, issued July 1, 1974

Dibblee, T. W., Jr., 1970, Regional geologic map of San Andreas and related faults in eastern San Gabriel Mountains, western San Jacinto Mountains and vicinity: U.S. Geological Survey Open-file map, scale 1:125,000.

Envicom Corporation, 1974, Preliminary geologic/seismic subsurface investigation, Soboba Properties, Inc., Soboba Springs, California: Unpublished consulting report dated June 21, 1974.

Fairchild Aerial Surveys, 1938, aerial photographs C-5405 #4 to 7, black and white, vertical, stereoscopic, scale 1:11,500 (Whittier College collection). (NE flight across Claremont fault, Soboba Springs.)

Fairchild Aerial Surveys, 1937, aerial photographs C-3931, #139 to 150, black and white, vertical, stereoscopic, scale 1:20,000 (Whittier College collection). (Covers Claremont fault from Hwy. Interstate 10 to Gilman Hot Springs.).

Fairchild Aerial Surveys, 1939, Aerial photographs C-5750, 209-71 to 209-78, 209-146 to 209-152, 210-17 to 210-25, 210-40 to 210-47, 210-85 to 210-91, and AXN 232-34 to 232-39, black and white, vertical, stereoscopic coverage, scale 1:20,000, Whittier collection. (Complete coverage of Hemet and San Jacinto quandrangles).

Fett, J. D., 1968, Geophysical investigation of the San Jacinto Valley, Riverside County, California: Unpublished MS thesis, University of California at Riverside, 87 p. (Provides data on the San Jacinto graben, including the principal bounding faults and the depth to bedrock based on gravity and seismic refraction data.).

Fett, J. D., Hamilton, D.H., and Fleming, F. A., 1967, Continuing surface displacements along the Casa Loma and San Jacinto faults in San Jacinto Valley, Riverside County, California: Association of Engineering Geologist Bulletin, V. 4, No. 1, P. 22-32. (Documents locations where surface displacement has occurred and attributes most or all of this to groundwater withdrawal.).

Fraser, D. C., 1931, Geology of San Jacinto quadrangle south of San Gorgonio Pass, California: California Division of Mines Report XXVII of the State Mineralogist, V. 27, p. 494-540.

Hart, E. W., 1977, Fault hazard zones in California --Alquist-Priolo Special Studies Zones Act of 1972 with index to Special Studies Zones Maps: California Division of Mines and Geology, Special Publication 42, revised January 1977, 24 p.

Lofgren, B. E., 1976, Land subsidence and aquifer-system compaction in the San Jacinto Valley, Riverside County, California -- a progress report: Jounal of Research, U.S. Geological Survey, V. 4, n. 1, p. 9-18. (Indicates long term subsidence due to compaction of upper 1237' (10 mm/yr) and deeper settlement (probably tectonic) of 3 to 6 mm/yr, based on extensometer measurements in well and levelling. Also indicates rise and fall of land surface, of 20 mm/yr related to rise and fall of water table (50' range) 1971-1974.).

Morton, D. M. 1977, Surface deformation in part of the San Jacinto Valley, southern California: Journal of Research, U.S. Geological Survey, v. 5, n. 1, p. 117-124.

Proctor, R. J., 1972, Geologic features of a section across the Casa Loma fault, exposed in an aqueduct trench near San Jacinto, California: Geological Society of America Bulletin, v. 73, p. 1293-1296. (Documents fault activity and describes fault and width of Casa Loma fault.).

Proctor, R. unpublished mapping (reportedly the same as Proctor, R., 1969, Geologic mapping of the San Jacinto quadrangle, California, section of San Jacinto Valley, drawing L 1094: Metropolitan Water District of Southern California).

Rasmussen and Assoc., 1977, Engineering geology investigation, Parcel map 9112, south of Cottonwood and Lyon Avenues, San Jacinto, California: Unpublished report A-P 412 on file with California Division of Mines and Geology (also filed as GR#65 in Riverside County).

Rasmussen, G. S., 1978, Alquist-Priolo Special Studies Zone along the NE side of Park Hill, Hemet, California: Unpublished report dated April 7, 1978, 12 p. and trench logs, plus supplement of April 12, 1978. (Contains detailed logs of sewer trench excavated continuously across zone encompassing "Park Hill fault.").

Rogers, T. H., 1965, Geologic map of California, Santa Ana Sheet, Olaf P. Jenkins Edition (scale 1:250,000).

Sharp, R. V., 1967, San Jacinto fault zone in the Peninsular Ranges of southern California: Geological Society of America Bulletin, v. 78, p. 705-730.

Sharp, R. V., 1972, Map showing recently active breaks along the San Jacinto fault zone between the San Bernardino area and Borrego Valley, California: U.S. Geological Survey Miscellaneous Geologic Investigations Map I-675.

Sharp, R. V., 1975, En echelon fault patterns of the San Jacinto fault zone in San Andreas fault in southern California: California Division of Mines and Geology, Special Report 118, p. 147-152. (Discusses relationship of Casa Loma and Claremont faults to San Jacinto Valley graben; shows principal faults on small scale map, fig. 3.).

Townley, S. D., and Allen, M. W., 1939, Descriptive catalogue of earthquakes of the Pacific Coast of the United States, 1769 to 1928: Bulletin of the Seismological Society of America, v. 29, n. 1, 297 p. (Provides brief summaries of 1899 and 1918 earthquakes centering in San Jacinto and Hemet; suggestion of ground rupture from San Jacinto southeastward into mountains.).

U.S. Geological Survey, 1967, aerial photographs WRD 5037 to 5208, black and white, vertical, stereoscopic, scale 1:12,000. (incomplete stereoscopic coverage; covers Casa Loma and Claremont faults.).

5. Available data

Official maps of Special Studies Zones (SSZ's) were issued July 1, 1974 for the Hemet and San Jacinto 7.5 - minute quadrangles. Zone boundaries were established for traces of the Casa Loma, Claremont, Park Hill and other faults of the San Jacinto fault zone within these quadrangles based on the work of Proctor (1969) and Sharp (1967; 1972), as indicated on Figure 3. Maps from these reports were the most detailed available at the time the SSZ maps were prepared. Also plotted on Figure 3 are the approximate locations of fault traces based on the 1:125,000 scale maps of California Department of Water Resources (1959) and Dibblee (1970). The latter references are in general agreement with Proctor and Sharp. An earlier map of Fraser (1931) is too generalized to be of use. As can be seen from Figure 3, some of the traces are well-located; others are approximately located or concealed. The concealed traces apparently were based both on the locations of groundwater barriers and on the projections of existing faults in areas covered by Holocene alluvium.

Since the 1974 SSZ maps were issued, about 100 site-investigations were required by Riverside County under the Alquist-Priolo Special Studies Zone's Act (Hart, 1977), and extensive trenching has revealed much new information about the locations and recency of faulting in the Hemet area. The location of the trenches and active (=Holocene) faults encountered are plotted on Figure 5. Most of the consulting reports identified are filed with CDMG in San Francisco (Room 1016, Ferry Building).

In order to properly identify the active faults for the purpose of rezoning, it is necessary to understand the structural setting of the Hemet area in terms of recent tectonics. According to Sharp (1975), the San Jacinto Valley is a graben (trough) formed by large-scale strike-slip faulting (estimated displacement is 15 miles) and extensional opening between the Claremont and Casa Loma-Clark faults. This relationship is shown in Figures 2a and 2b.

According to Fett (1968), the San Jacinto graben has subsided at least 8,000 feet in an area northwest of San Jacinto during late Cenozoic time. Radiocarbon age-dates determined for four wood samples obtained from water wells indicate a subsidence rate of 0.3 to 0.6 cm/yr during the last 40,000 years (Morton, 1977, P. 118; Lofgren, 1976, p. 12). This suggests that most of the subsidence occurred during late Quaternary time. Holocene subsidence has continued, as demonstrated by the youthful scarps in alluvium, along the Claremont and Casa Loma faults (see Figures 4a and 4b). The subsidence rate in the last 50 years or so apparently has increased as a result of groundwater withdrawal and irrigation causing both large-scale lowering of the water table and hydrocompaction. Measurements indicate that maximum induced subsidence is about 3.5 cm/year (Morton, 1977, p. 123). Evidence of on-going differential settlement along segments of the Casa Loma and Claremont faults is indicated by cracks in roadways and the open fissures and sink holes developed in alluvium along known faults (Fett, et al, 1967 and my observations).

With the exception of suggested right-lateral slip of 3.5 cm between 1958 and 1973 where an aqueduct pipe crosses the Casa Loma fault (Morton, 1977), historic right-slip displacement has not been documented for the faults in the Hemet area. However, there is evidence of late Holocene right-lateral displacement of the modern drainage channels and alluvial fans along the Claremont fault within the study area (see Fig. 4b). There also is indirect evidence of strike-slip displacement in several trench exposures across the Casa Loma and Claremont faults (see logs of reports A-P 334 and 708).

Subsequent to issuance of the SSZ maps in 1974, the County of Riverside required site investigations for development projects within the SSZ's. Most of the investigations were conducted by the consulting firms of Gary L. Rasmussen and Lewis Lohr of Hemet. Nearly all the investigated sites were explored by deep trenching. Because the San Jacinto Valley is underlain by late Holocene alluvium, this resulted in a wealth of data on the locations of active faults traces, which are plotted on Figure 5. The active faults encountered largely coincide with the recent scarps observed in young alluvium (see Figure 4a and 4b and discussion under item 6 below). Trenching also reveals that active faulting is discontinuous, and locally the zones of active fault strands are as wide as 2,000 feet. Based on the available data, the several faults identified on Figure 5 are discussed individually below in terms of their recency of activity and certainity of their location.

Casa Loma fault

Northwest of Park Hill, this fault is well defined by Holocene fault scarps as mapped by Sharp (1972). However, the fault breaks into multiple strands near Park Hill, where the zone is complex and wide. Faulting is down to the northeast, as would be expected for a fault bounding the southwest side of a graben, except near Park Hill. Active traces could not be followed along the southwest side of Park Hill and surface faulting may be discontinuous and partly distributed as monoclinal flexures. South of Park Hill the zone is complex but can be followed for more than a mile southeast of Florida Avenue. Although the fault presumably connects at depth with the Clark fault to the southeast (Sharp, 1972 and 1975) its surface location is unknown. A buried, northeast-facing, basement scarp generally verifies its location, however (Fett, 1968). Even so, the subsurface location is known only crudely (John Fett, p.c., 1978). There is no indication of the surface location on aerial photographs examined (Figure 4a).

Park Hill fault

This is an inferred ground water barrier (California Department Water Resources, 1959; Proctor, 1969; Sharp, 1972), but its precise location is unknown. Although the fault is assumed to exist and very likely bounds Park Hill (a pressure ridge?), there is no evidence of the fault's location at or near the ground surface nor of its activity during Holocene time. Two minor faults were identified by Rasmussen (1978) in a sewer-trench cut along Washington Avenue and these are shown on Figure 5. The fault just west of Hewitt Street trends northeast and offsets alluvium of probable Holocene age by 3.5 feet (Figure 6). This fault coincides with a tonal lineament in soil as shown in Figure 4b. The fault was not clearly identified in a trench cut in Holocene alluvium 300-400 feet to the northeast (Figure 6). However a 2-inch offset at a depth of 9 feet conceivably could be the northeast continuation of the feature. However, a bed at 7 feet of depth is not offset by the feature, indicating recent inactivity. Rasmussen (1978, p. 1 of April 12, 1978 supplement) concludes that the northeast-trending feature is due to ground failure from seismic shaking and is not a "tectonic fault." The feature was not traced to the southwest, but it cannot extend beyond the most easterly strand of the Casa Loma fault 2,000 feet away. The area to the southwest is now developed and covered by homes and streets.

Another minor fault-like feature was encountered in the sewer trench along Washington Street, 3,300 feet east of Hewite (Rasmussen, 1978). This feature trends N 32° W and offsets Holocene alluvium by 7 inches at a depth of 7.5 feet but not the young surface layers at a depth of 2 feet. A second trench cut just north of Washington Street and on-trend with the feature did not encounter the fault in the same alluvial materials. Rasmussen concludes that the feature is not through-going and probably is the result of seismic shaking. There is no surface evidence of this feature.

Inferred Fault A

A "possible fault" is identified by Rasmussen (1977, p. 5,9) 2,000 feet northeast of the main trace of the Casa Loma fault. Although the basis for inferring this fault is not stated, it is presumed that the modified northeast-facing escarpment is the basis of the inference. The inferred trace is the southeast half of the trace shown in this report on Figures 4b and 5. It is described further under item (6) below.

Inferred Fault B

This trace (Figure 5) is located slightly to the northeast of the one shown by Rasmussen (1978, Enclosure 1), but reportedly represents a northwest-trending southwest facing, broad escarpment about 3 feet high. (Rasmussen, p.c., 1978). This feature, which occurs in Holocene alluvium, is discussed below under item (6).

Claremont Fault

This fault is a major strand of the San Jacinto fault zone, defining the northeast boundary of the San Jacinto Valley graben (Sharp 1972, and 1975). The fault has had major strike-dlip displacement (measured in miles) to the northeast, but it also has an important dip-slip component (down to the southwest a maximum of 8,000 feet or more). Figure 3 indicates disagreement in the precise locations of the principal strands, but this is believed to be due mainly to the lack of detailed mapping. The active traces of the Claremont fault are indicated by young topographic features identified on Figure 4b and discussed additionally under item 6 below. This work indicates that Proctor's 1969 unpublished mapping is the most accurate previous work available. Locations of active traces have been documented at 4 localities: Cracks have developed in Highway 79 and at the bridge across Massacre Canyon (Fett, et al, 1967, p. 29). Although the road has been repaired, the cracks have reappeared both north and south of the bridge. Also, a fault with N40° W-trend and 60° SW dip exposes faulted older alluvium just north of the bridge. About half-a-mile northwest of Soboba Springs, near an old kiln, sink holes reportedly developed along the old highway (Fett, et al, 1967, p.27, and Fett, p. 6, 1978). A third locality is half a mile south of Soboba Springs where trenching by Envicom (1974) revealed faulting within Holocene alluvium. Here the fault occurs forms a southwest-facing scarp and the zone of active faulting is at least 50 feet wide (southwest side down mainly, but some evidence of strike-slip juxtaposition). At a fourth locality, a mile northwest of Valle Vista and just east of Bautista Creek, two trenches expose a 70-foot wide zone of faults (down to the west) in late Holocene alluvium (A-P 573). This fault zone generally aligns with a pronounced west-facing scarp north of the San Jacinto River (see Figures 4b and 5). There is no surface or subsurface evidence as to the location of the Claremont fault south of the site of A-P 573 although deep trenching has been conducted across the entire SSZ.

There is no surface or subsurface evidence for the concealed trace of the Claremont fault shown by Sharp (1972) and used to establish the initial SSZ in 1974.

Inferred Fault C

This inferred concealed trace is based on Sharp (1967) and was used as a basis for zoning (Figure 3). Presumably it is the inferred connection between the Claremont fault and the southeast extension of the Casa Loma fault which must connect with the active Clark fault of Sharp (1972). In spite of extensive deep trenching along and north of Mayberry Avenue, there is no evidence of such a fault at or near the ground surface. No other geologists have mapped this inferred fault.

Inferred Extension of Park Hill Fault

This inferred fault is shown to be concealed under alluvium by Sharp (1967) and as doubtful by CDWR (1959). The fault is an inferred extension of the Park Hill fault, but no specific surface or subsurface evidence supports its existence. Moreover, no evidence for it was observed on aerial photographs interpreted by me.

Fault D

This fault, shown by Proctor (1969), was zoned in 1974 under the assumption that it is the southeast extension of the Claremont fault. However, it is not known to extend to the southeast as an active or important Quaternary fault (Sharp, 1967) and is not shown by CDWR (1959) or Dibblee (1970). Even so, the abrupt linear escarpment in Bautista Beds (Plio-Pleistocene) and its alignment with the Claremont fault suggests youthful faulting. However, small alluvial fans at the base of the escarpment and the late Pleistocene terrace surface north of Poppet Creek show no evidence of fault disruption. It may be that the escarpment is largely erosional, possibly being controlled by pre-Holocene faulting.

Hot Springs Fault

The northwest end of this fault is recognized by all geologists from the abrupt scarp of granitic/gneissic rocks which are juxtaposed against soft Plio-Pleistocene Bautista Beds (e.g. Frasor, 1931; CDWR, 1959; Proctor, 1969; Dibblee, 1970). Although of east-west trend in the study area, the fault is shown to extend southeasterly beyond the study area for many miles (Figure 1). However, not all workers agree on the location, or even the existence, of the fault in the San Jacinto quadrangle east of Castile Canyon in Section 29 (Figures 3 and 4b). Based on air photo interpretation (Fibure 4b), there is no evidence that the Bautista Bed or geomorphic features are offset by active faults in the vicinity of Castile Canyon and the high scarp to the west may be largely a fault-line scarp. The prominent scarp between Soboba Springs and Castile Canyon apparently is at least partly the result of differential erosion and landsliding. According to Gary Rasmussen (p.c. 1978), and old-time resident of the area reported large-scale landsliding off the front of the south-facing scarp following the 1918 earthquake. As a result, it cannot be demonstrated that active faulting has not occurred along west of Castile Canyon.

Another scarp between granite and Bautiste Beds also exists at the head of Poppet Creek. This contact has been mapped as a fault by Proctor (1969). There is no evidence that this segment connects directly with the Hot Springs segment to the west. Holocene activity cannot be demonstrated for the segment at the head of Poppet Creek, but neither can it be denied.

6. Interpretation of Aerial Photos and Field Checking

A detailed review and interpretation of old aerial photographs (Fairchild, 1937, 1938 and 1939) available at Whittier College was made in order to identify all significant faults and to evaluate the recent fault features. These photos provided excellent stereoscopic coverage. WRD series photos of the USGS (1967) also were examined but did not provide complete stero coverage. Fault features and annotations based on photo interpretations are plotted on Figures 4a and 4b. Data from field observations, made November 8-9, 1978, also are plotted on Figures 4a and 4b.

This work clearly identifies thosefault segments that are well-defined by scarps. Locations of other fault segments are obscurred by recent sedimentation and the shifting of drainages. Deep trenching (Figure 5) has greatly assisted in locating active fault traces in some areas. However, the Casa Loma fault is comprised of numerous discontinuous traces which die out laterally or pass into broad warps in the poorly consolidated (though well-stratified) alluvium. Thus, it is not known how the north and south segments of the Casa Loma fault connect west of Park Hill. Even less is known about the surface locations of the Casa Loma and Claremont faults where they converge to the southeast of Park Hill. It may be that the faults do not propagate through the alluvium to the ground surface or that sedimentation is so rapid that the faults are buried by very young alluvium.

The Claremont fault is more difficult to interpret because it is crossed by alluvial fans or obscured by erosion and sedimentation processes of the San Jacinto River. Even so, the high southwest-facing scarp of the San Jacinto Mountains and the position of the San Jacinto River (aggrading drainage) on the northeast side of the valley, strongly indicate that recent subsidence and faulting is greater along the Claremont fault than along the Casa Loma fault.

No evidence was observed on the air photos or in the field that suggested active faulting for the Park Hill fault, its extension, or the southern extensions of the Casa Loma and Claremont faults (including inferred fault C). Inferred fault B is a very subtle, low scarp that may be due to erosion rather than faulting. It can be traced only for about 2,000 feet. If it is a fault, it is a minor one. Inferred fault D is described above under Item 5.

Inferred fault A is a linear feature at least 4,000 feet long, as depicted on Figure 4b. The north-west end is a very well-defined scarp about 5 feet high. The pavement of Lyon Avenue, is stressed about half way up the scarp where tensional cracks and a small trough (sink holes below?) are developed, both with a northwest trend. On-trend to the southeast is a distressed out-building (not examined, closely). These features are most likely associated with recent subsidence over a pre-existing fault (scarp in Holocene alluvium) of the Casa Loma fault. Other northwest-trending scarps and tonal lineaments about 700 feet to the northeast may represent another secondary fault, but these features cannot be readily evaluated, partly because the scarp is obscured by the reservoir.

The tonal lineament that trends northeast across Washington Avenue west of Hewite is very minor and would be ignored except for the fault-like features encountered by trenching (Rasmussen). Other tonal lineaments exist (Figure 4a and 4b), but some of these are attributed to channel deposits or have an unknown origin.

7. Conclusions

It is concluded that the Claremont and Casa Loma faults are clearly active and mostly well-defined. However, the traces of these faults are locally undetermined, even though the faults certainly must connect with the active Clark fault to the southeast. The Park Hill fault probably exists at depth, but there is no solid evidence that it is active and its general location is only inferred from indirect evidence. This view is similar to that of Rasmussen, 1978.

8. Recommendations

Recommendations regarding rezoning (based on traces shown in Figure 5) or the need for additional work is made for the individual faults as follows:

a. Casa Loma fault and inferred fault A -- relocate zone boundaries based on the known fault traces. Retain the zones southeast of Johnston Avenue, unless new information permits a relocation.

b. Claremont fault - - delineate a narrower SSZ based on traces shown in Figure 5. Terminate the zone at the south boundary of the San Jacinto quadrangle. If time permits, additional air photo and field work should be conducted in the vicinity of Valle Vista and the hills south of there to determine if an active fault connections exists with the Clark fault (there is some evidence of complex faulting in the Bautista Beds in this area).

c. Park Hill fault - - delete zone, including the inferred extension.

d. Fault B - - probably too minor to zone; check other photos if available and field check if time permits.

e. Fault D - - no change recommended unless further field or photo checking indicates fault is not active (see Supplement No. 1).

f. Hot Spring fault - - revise zone to fit relocated traces.

g. Unnamed fault east of fault A (Figure 4b) -- do not zone; if time permits, check roads and reservoir perimeter for subsidence effects.

h. Inferred fault C. Delete zone; no evidence exists that would indicate the surface or near surface position of this inferred, concealed fault.

9. Report prepared by: E. W. Hart, 1/23/79

Earl W. Hart

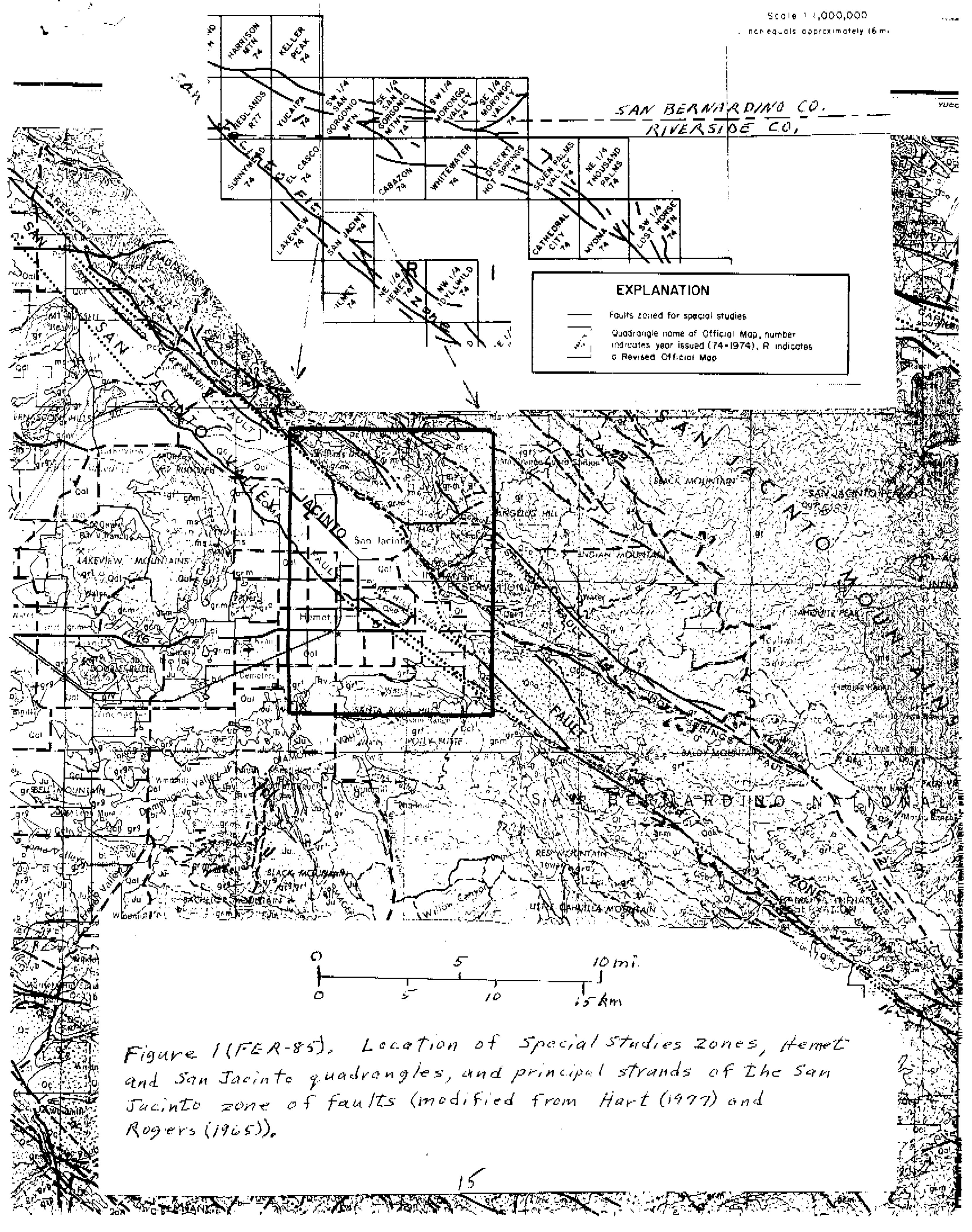


Figure 1(FER-85). Location of Special Studies zones, Hemet and San Jacinto quadrangles, and principal strands of the San Jacinto zone of faults (modified from Hart (1977) and Rogers (1965)).

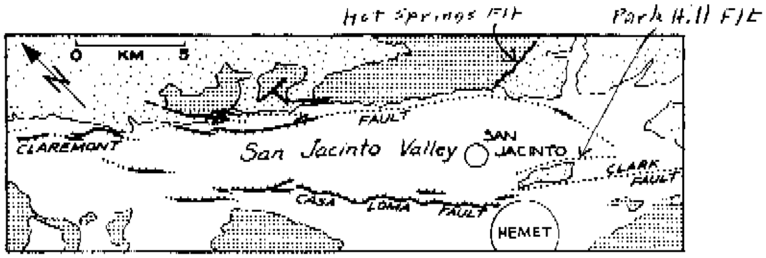


Figure 2a. Fault pattern in San Jacinto Valley. Heavy lines are faults, hachures on downthrown sides. Dark stipple: Mesozoic and older crystalline rocks. Light stipple: Pliocene and Pleistocene continental sedimentary rocks. Unstippled areas: Quaternary alluvium. (After Sharp, 1975.)

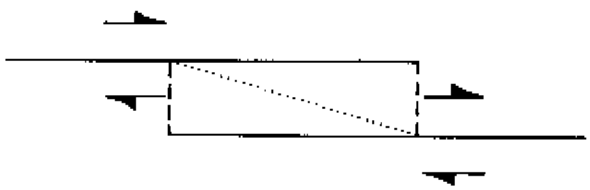
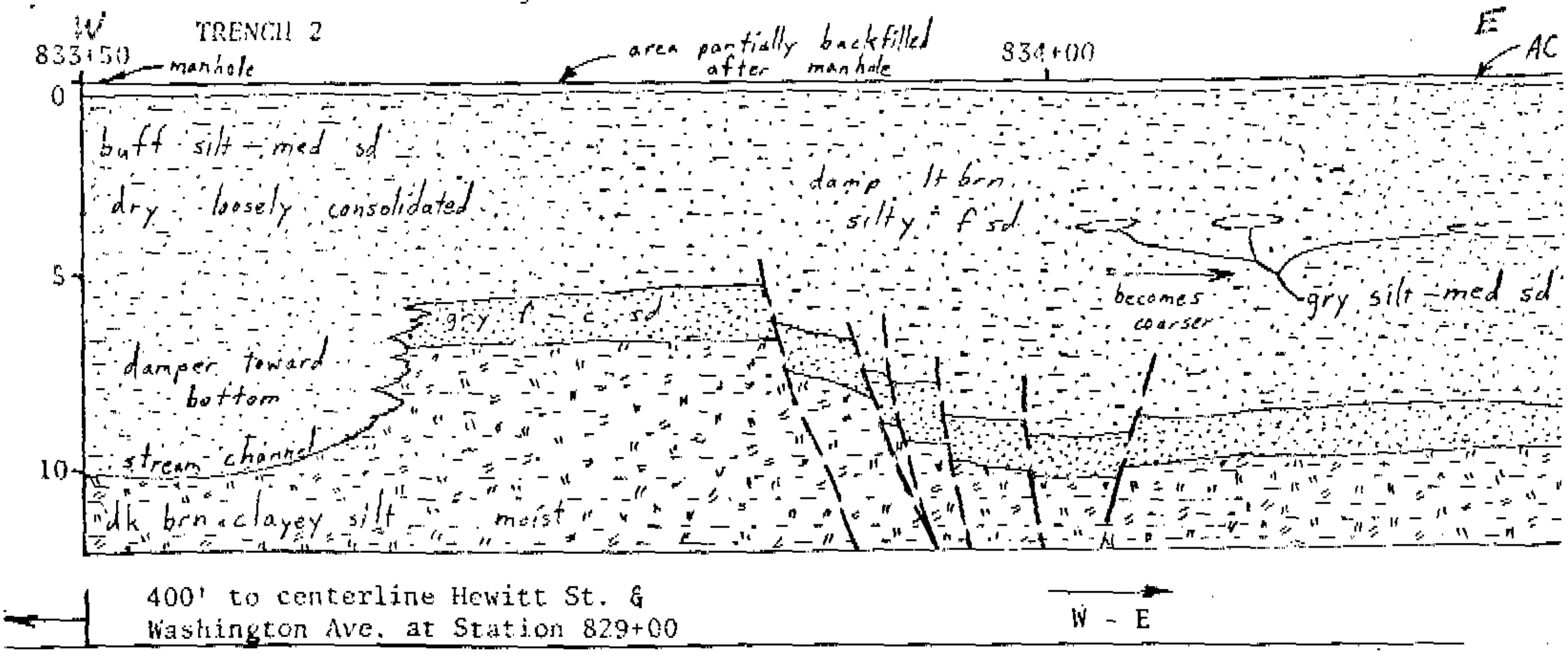


Figure 2b. Diagram of overlapping en echelon faults. Solid lines are fault traces, dashed lines bound area of overlap, dotted line shows possible orientation of single fault at depth. Arrows show direction of relative movement. (After Sharp, 1975.)



Logged by JRS & ELB

Horizontal scale 1"=10'
Vertical scale 1"=5'

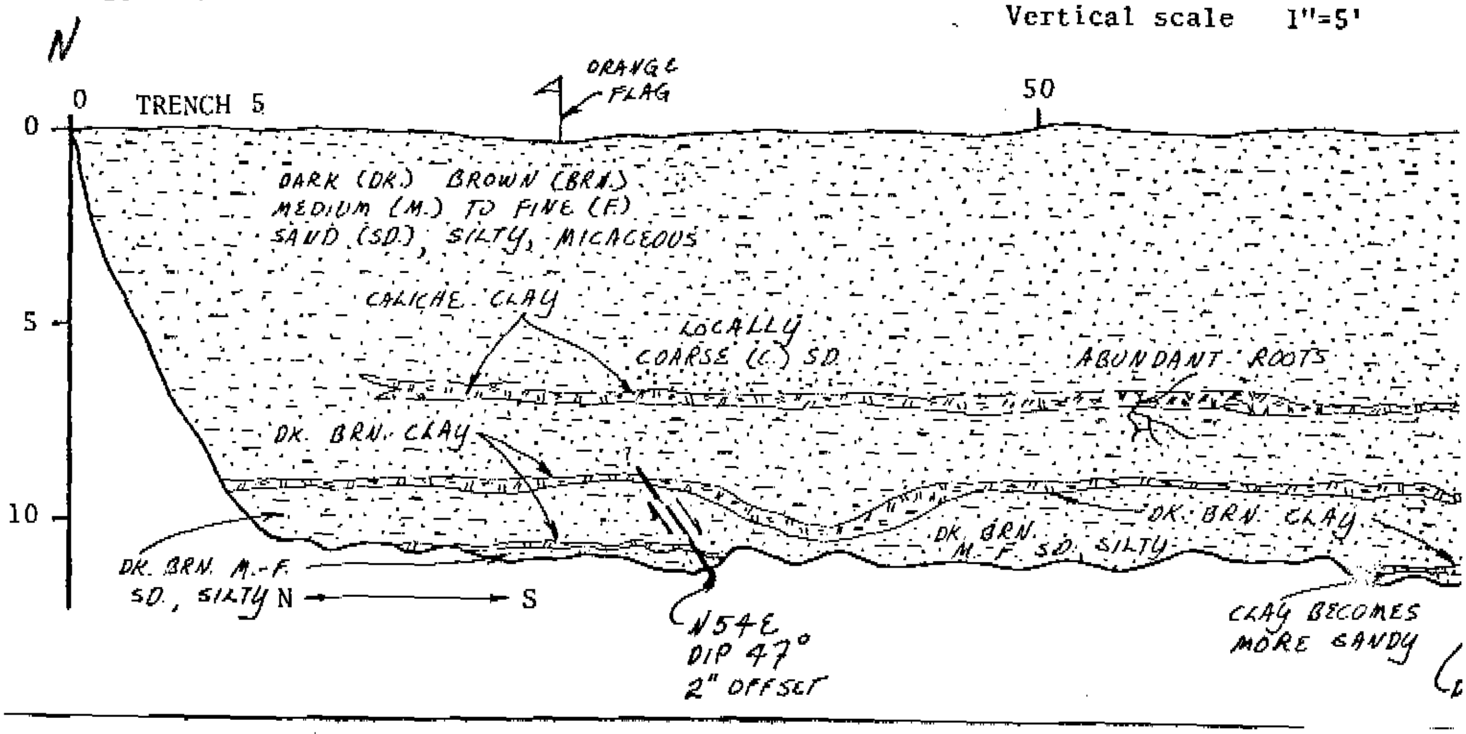


Figure 6. Portions of Trench 2 (sewer trench) and Trench 5 of Rasmussen (1978), who considers these northeast-trending fault-like features to be due to seismic shaking.